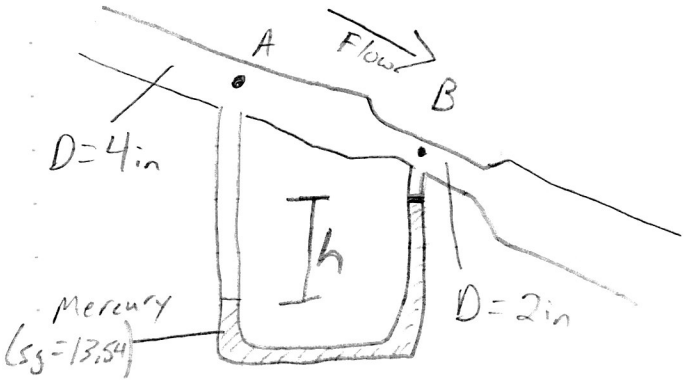
Homework 1.3 Chapter 6 — Giant Falcon

6.79 Oil with a specific gravity of 0.90 is flowing downward through the venturi meter shown in figure. If the manometer deflection h is 28 in, calculate the volume flow rate of oil.



$\gamma_{Hg} = (13.54)(62.4\ lb/ft^3)$
$\gamma_{Hg} = 844.9\ lb/ft^3$

$\gamma_{oil} = (0.90)(62.4\ lb/ft^3)$
$\gamma_{oil} = 56.16\ lb/ft^3$

We know $\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B$ ①

$\rightarrow \frac{P_A - P_B}{\gamma} + (Z_A - Z_B) = \frac{V_B^2 - V_A^2}{2g}$

Manometer: $P_A + \gamma_{oil}\left(28in\left(\frac{1ft}{12in}\right)\right) - \gamma_{Hg}\left(28in\left(\frac{1ft}{12in}\right)\right) - \gamma_{oil}(Z_B - Z_A) = P_B$

$\rightarrow P_A - P_B = -(56.16\ lb/ft^3)(2.333ft) + (844.9\ lb/ft^3)(2.333ft) + (56.16\ lb/ft^3)(Z_B - Z_A)$

$\rightarrow P_A - P_B = -131.02\ lb/ft^2 + 1971.2\ lb/ft^2 + (56.16\ lb/ft^3)(Z_B - Z_A)$

$\rightarrow P_A - P_B = 1840.2\ lb/ft^2 + (56.16\ lb/ft^3)(Z_B - Z_A)$

$\rightarrow \frac{P_A - P_B}{\gamma_{oil}} = 32.77ft + (Z_B - Z_A)$

So for ① $32.77 + \cancel{(Z_B - Z_A)} + (Z_A - Z_B) = \frac{V_B^2 - V_A^2}{2g}$

We know $A_A \cdot V_A = A_B \cdot V_B \rightarrow V_B = V_A\left(\frac{A_A}{A_B}\right)$

$\rightarrow V_B = V_A\left[\left(\frac{\pi D_A^2}{4}\right) / \left(\frac{\pi D_B^2}{4}\right)\right]$

$\rightarrow V_B = \left(\frac{D_A^2}{D_B^2}\right) V_A$

$\rightarrow V_B = \left(\frac{(4in)^2}{(2in)^2}\right) \cdot V_A = 4V_A$

So for ① $32.77ft = \frac{(4V_A)^2 - V_A^2}{2g} \rightarrow 2110.4\ ft^2/s^2 = 15V_A^2$

$\rightarrow V_A = 11.86\ ft/s$

Then $Q = A_A \cdot V_A = \left(\frac{\pi(4in \cdot \frac{1ft}{12in})^2}{4}\right)(11.86\ ft/s) = \boxed{1.035\ ft^3/s}$

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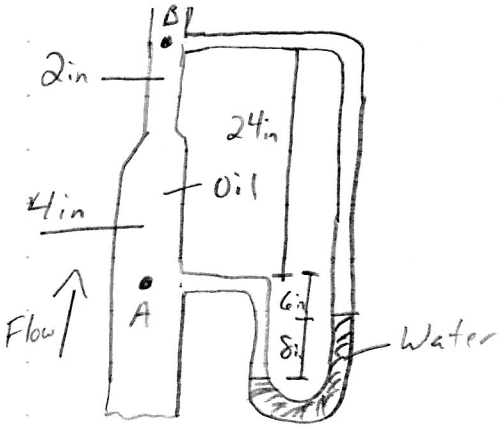
6.82 Oil with a specific weight of 55.0 lb/ft^3 flows from A to B through the system shown in figure. Calculate the volume flow rate of the oil.



We know $A_A V_A = A_B V_B$

$\rightarrow \left(\frac{\pi (4in)^2}{4}\right) V_A = \left(\frac{\pi (2in)^2}{4}\right) V_B$

$\rightarrow V_B = 4 V_A$

We know $\frac{P_A}{\gamma} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\gamma} + \frac{V_B^2}{2g} + Z_B$

$\rightarrow \frac{P_A - P_B}{\gamma} + (Z_A - Z_B) = \frac{V_B^2 - V_A^2}{2g}$ (1)

Manometer: $P_A + \gamma_{oil}(14in \cdot \frac{1ft}{12in}) - (62.4\ lb/ft^3)(8in \cdot \frac{1ft}{12in}) - \gamma_{oil}(30in \cdot \frac{1ft}{12in}) = P_B$

$\rightarrow P_A - P_B = 1.33ft \cdot \gamma_{oil} + 41.6\ lb/ft^2$

$\rightarrow \frac{P_A - P_B}{\gamma_{oil}} = 1.33ft + 0.756ft$

$\rightarrow \frac{P_A - P_B}{\gamma_{oil}} = 2.086ft$

So for (1) $2.086ft + (-24in \cdot \frac{1ft}{12in}) = \frac{(4V_A)^2 - V_A^2}{2g}$

$\rightarrow 0.086ft = \frac{15 V_A^2}{2g}$

$\rightarrow V_A = 0.6076\ ft/s$

Then $Q = A_A \cdot V_A = \left(\frac{\pi (4in \cdot \frac{1ft}{12in})^2}{4}\right)(0.6076\ ft/s) = \boxed{0.053\ ft^3/s}$

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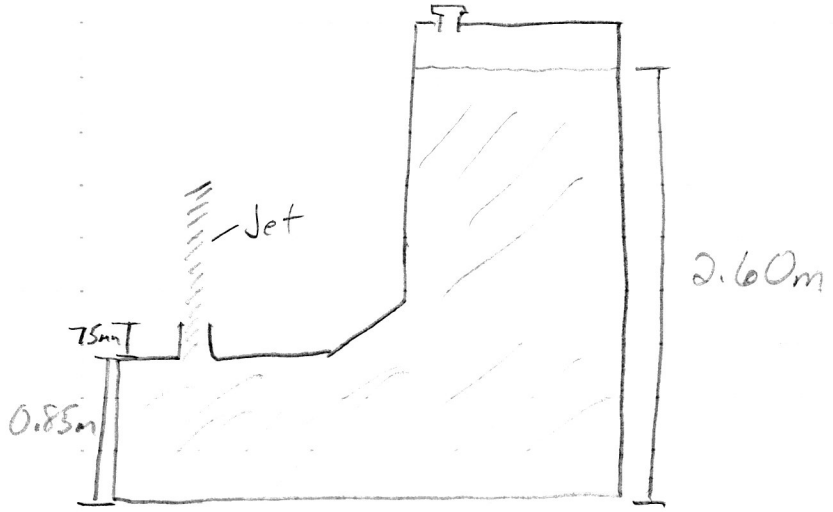
6.91 To what height will the jet of fluid rise for the conditions shown in figure.



Using the gamma-H equation we have

$$P_{jet} = 2.60m \cdot \gamma_F - 0.85m \cdot \gamma_F - 0.075m \cdot \gamma_F$$
$$P_{jet} = 1.675m \cdot \gamma_F$$

Therefore, the value of h for the pressure at the nozzle of jet is $\boxed{1.675m}$